Wireless Technology for In-Building HVAC Sensing and Control Applications

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Wireless Technology as Enabler for Building Operations

- Enables:
  - Better control for energy efficiency
  - Enables automated diagnostics and commissioning
  - Improved life-time of HVAC equipment
  - Improved comfort
  - Supports demand response
- How:
  - Cost reduction potential by avoiding labor for wiring (20-80% of the installation cost of controls)
  - Mobility

Objective of Demonstration

- Analyze cost-effectiveness of wireless sensors in large office buildings
  - Analyze installation efforts
  - Test robustness of communications
  - Analyze maintenance requirements
  - Compare cost (wireless vs. wired systems)
  - Lessons learned
    - Potential problems
    - Ideal applications versus marginal applications
    - Other issues

Wireless Sensors and Controls

PNNL 337 Building

- about 70,000 sq. ft. office space
- 3 floors
- steel-concrete construction
- built-up HVAC System
- wireless temperature sensors 1

PNNL EMSL Building

- one wing is instrumented
- about 15,000 sq.ft.
- 2 floors
- steel-concrete construction
- wireless temperature sensors 1 2

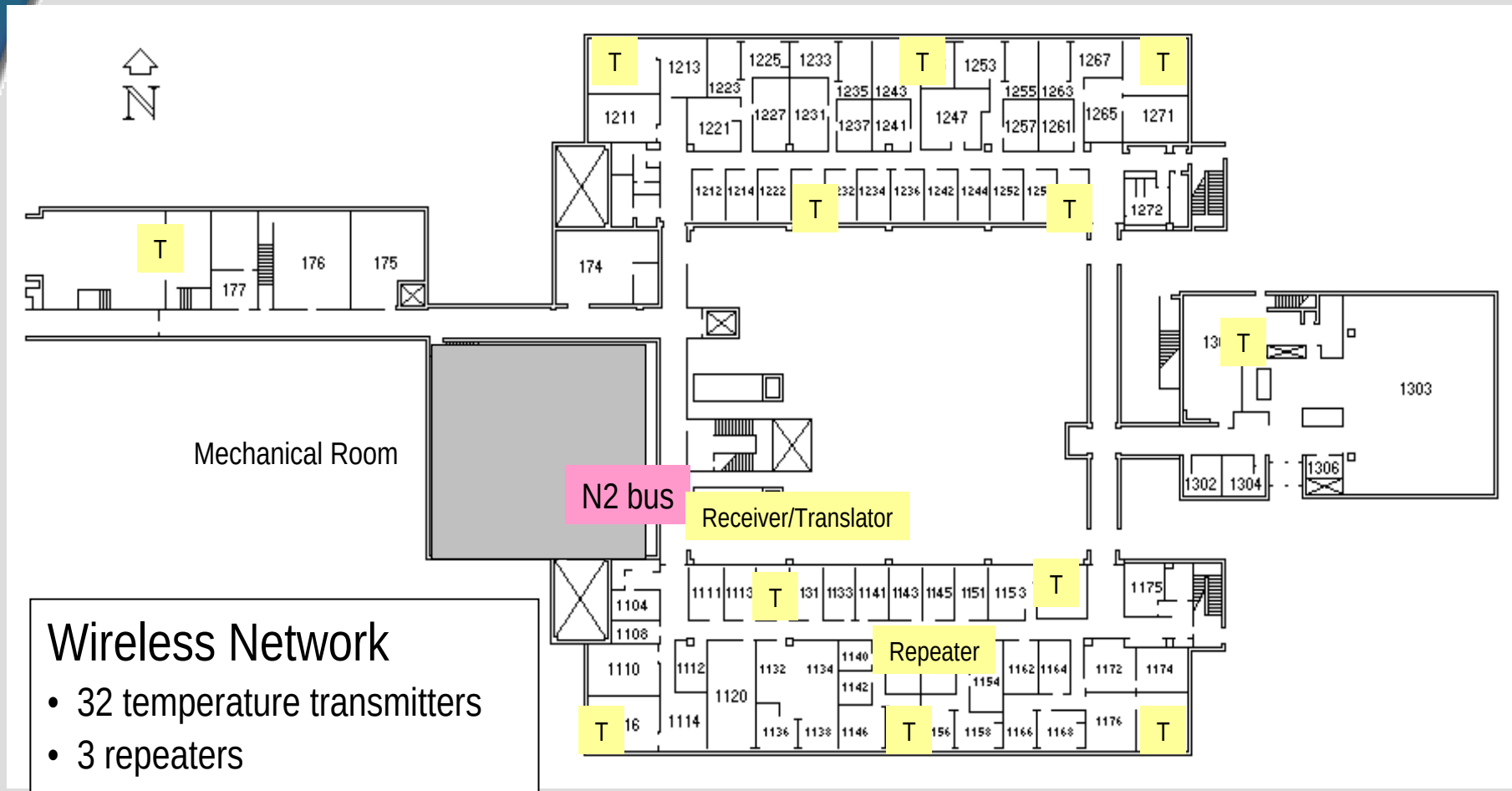
Building 1

1

- about 70,000 sq. ft. office space
- steel-concrete construction
- 3 floors
- Built-up HVAC system

- Federally owned
- Operated by Battelle

Wireless Network Topology, Bld 1 1



Wireless Network

- 32 temperature transmitters
- 3 repeaters
- 1 receiver/translator

Wireless Sensor Network Technology

1

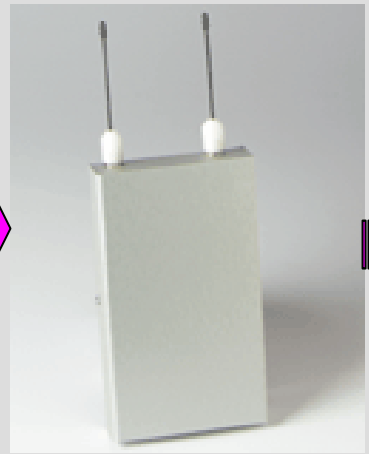
Battery-powered Temperature **sensor** and **transmitters**

Repeater

Receiver

Translator
From wireless to N2 bus

BAS



Translator

- **900 MHz**
- **FHSS**
- **Range: 2500 ft.**
- **Battery life: 3 y**
- **Sensor: RTD**

- **Line powered**
- **Range: 4 miles**

- **Up to 100 transmitters**

Cost Comparison: Wireless vs. Wired at Building 1 [1]

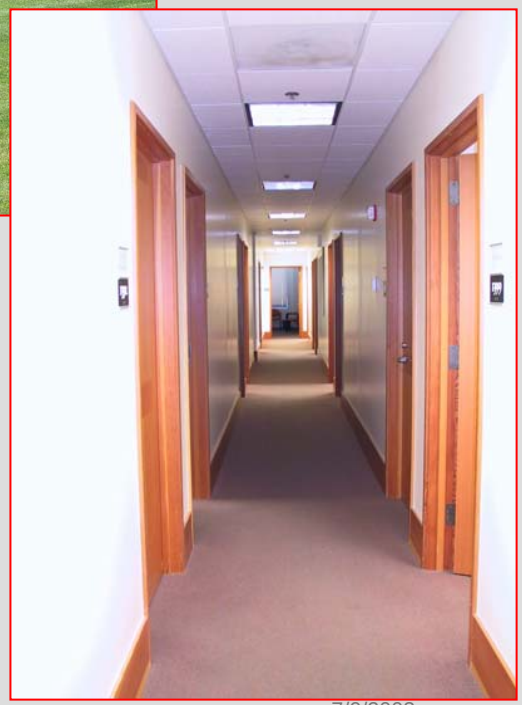
- **WIRELESS:** wireless system for 32 nodes
  - **About $210/sensor** for wireless
  - Installed cost: $6300
  - Operating cost for exchanging batteries every 3-5 years
- **WIRED:**
  - **$220/sensor**, including temperature sensors
- **Competitive Advantage of Wireless over Wired**
  - Easily extendable given seamless wireless coverage
  - PNNL Facility staff is experimenting with wireless emergency lighting ballast monitoring.
    - Large cost savings by avoiding
      - visual inspection (monthly, annually)
      - paperwork (self-documenting in BAS)
    - 60 additional nodes in wireless network => **$130/sensor**

Lessons Learned

- Wireless networks work very reliably, since Spring 2002
- Facility staff fully embraced wireless technology as enabling technology
  - Diagnostics:
    - Heat buildup in kitchen
    - Cold spots in zones led to reset of the entire building temperature, thus avoiding overcooling and use of space heaters
  - Monitor emergency lighting ballasts
- Control Strategy:
  - Chilled water reset strategy based on averaged zone temperatures as proxy for meeting load.
  - $6000 cost savings per year
  - Payback: 6 – 12 months
- Communication to occupants was necessary to explain new technology.

Building 2

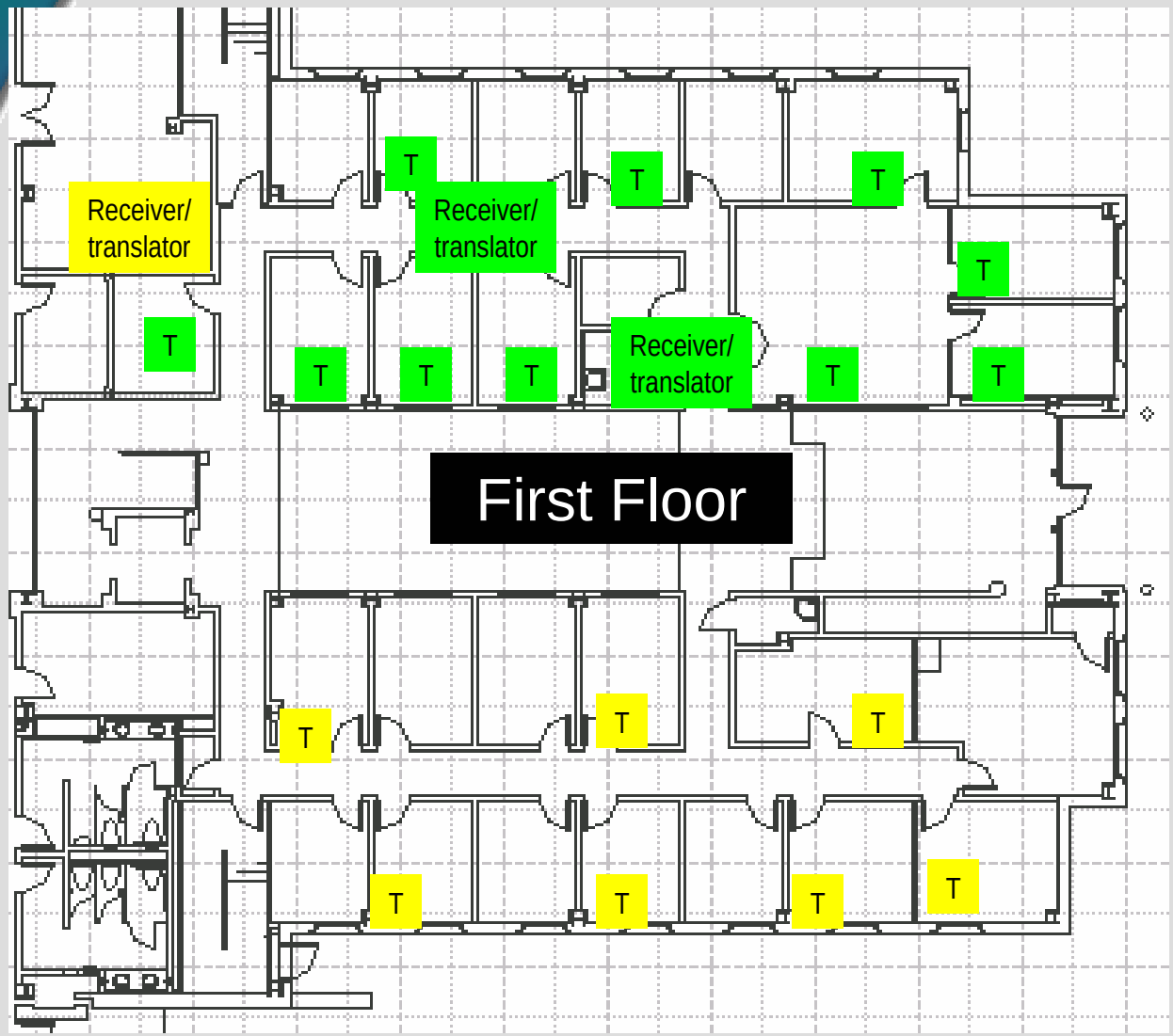
1 2



- 15,000 sq.ft.
- 2 Floors
- Central open space
- 56 offices on two corridors
- Walls
  - Metal studs
  - Gypsum wall board
- Ceiling:
  - Metal sheeting
  - Concrete floor

Wireless Network Topology – Bld. 2

1 2



North wing (2 floors)
- 3 receivers/translators
- 20 temperature transmitters

South wing (2 floors)
- 1 receiver/translator
- 20 temperature transmitters

Wireless Sensor Network Technology 2

Battery-powered temperature **sensor** and **transmitters**

No repeater

Receiver transmitters

Translator from wireless to N2 bus

BAS

Translator

- **300 MHz**
- **Range: 300 ft.**
- **Battery life: 5 y**
- **Sensor: IC**

Wireless Technology at Building 2

- Control Strategy: Night setback for ventilation
- Need: temperature monitoring in each office

Technology 1

- Hardware
  - 20 transmitters
  - 1 receiver
  - 1 translator
- Characteristics
  - Range about 100 ft. in building
  - 3 year battery life
  - RF survey: 30 min.
- Cost
  - $80/node

Technology 2

- Hardware
  - 20 transmitters
  - 3 receivers
  - 3 translators
- Characteristics
  - Range about 40 ft. in building
  - 5 years battery life
  - RF survey: 1 hour
- Cost
  - $100/node

Lessons Learned

- RF-surveying for locating receiver/translator and repeater
  - Requires training
  - Now done by controls specialists
- Installation and setup
  - Straight forward
- Operation has been flawless since Spring 2002
- Facility staff fully embraced wireless technology as enabling technology
  - Diagnostics
  - Monitor emergency lighting ballasts
  - Other energy-efficiency opportunities
    - Shut-off of fans when garage door open
    - Tightening operating schedules of HVAC
    - Demand-controlled ventilation
    - Demand responsiveness
- Considerations
  - Vulnerability clearance for wireless system
  - Perceived BIG BROTHER IS WATCHING YOU mentality
  - Theft

Questions ?